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THESIS

INCREASING REALISM IN VIRTUAL MARKSMANSHIP SIMULATORS
by
Brian P. Worden
December 2012

Thesis Advisor:	Rudy Darken
Second Reader:	Steve Iatrou

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13. ABSTRACT (maximum 200 words)

The U.S. military currently uses a number of virtual marksmanship simulators to help train its soldiers and Marines in marksmanship techniques. Like all information systems, these virtual marksmanship simulators rapidly become outdated, and need to be upgraded or replaced. One aspect that can potentially be improved is the "realism" of these simulators, generally in regards to their graphics quality. The issue is that simulator realism is a highly complex subject, with many more factors to account for besides just graphics quality. The author hypothesized that (1) one or more specific factors can be identified which impact the realism of virtual marksmanship simulators, and (2) improving or enhancing a factor, such as graphics quality, will have a positive effect on a participants objective score and/or their subjective experience with the simulator.

A group of 17 civilian and active-duty military volunteers conducted baseline training with the Indoor Simulated Marksmanship Trainer (ISMT), and then participated in two different scenarios using the standard Navy Handgun Qualification Course (NHQC). One scenario used a low-resolution background, while the other used a high-resolution background.

Results partially supported the hypotheses. While no conclusive objective data identified any specific factors that impact the realism of virtual marksmanship simulators, there was subjective data to suggest that graphics quality did impact the realism of virtual marksmanship simulators. Likewise, the objective data taken from shooters' scores showed no improvement between low-resolution and high-resolution scenarios, but the subjective experience of the participants trended positively toward higher fidelity graphics.

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INCREASING REALSIM IN VIRTUAL MARKSMANSHIP SIMULATORS

Brian P. Worden
Lieutenant, United States Navy
B.S., Rensselaer Polytechnic Institute, 2006

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December 2012

Author: Brian P. Worden

Approved by: Rudy Darken
Thesis Advisor

Steve Iatrou
Second Reader

Dan Boger
Chair, Department of Information Sciences

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ABSTRACT

The U.S. military currently uses a number of virtual marksmanship simulators to help train its soldiers and Marines in marksmanship techniques. Like all information systems, these virtual marksmanship simulators rapidly become outdated, and need to be upgraded or replaced. One aspect that can potentially be improved is the “realism” of these simulators, generally in regards to their graphics quality. The issue is that simulator realism is a highly complex subject, with many more factors to account for besides just graphics quality. The author hypothesized that (1) one or more specific factors can be identified which impact the realism of virtual marksmanship simulators, and (2) improving or enhancing a factor, such as graphics quality, will have a positive effect on a participants objective score and/or their subjective experience with the simulator.

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Results partially supported the hypotheses. While no conclusive objective data identified any specific factors that impact the realism of virtual marksmanship simulators, there was subjective data to suggest that graphics quality did impact the realism of virtual marksmanship simulators. Likewise, the objective data taken from shooters’ scores showed no improvement between low-resolution and high-resolution scenarios, but the subjective experience of the participants trended positively toward higher fidelity graphics.

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LIST OF ACRONYMS AND ABBREVIATIONS

CO_2	Carbon Dioxide
CGI	Computer-generated imagery
FMV	Full Motion Video
ISMT	Indoor Simulated Marksmanship Trainer
IRB	Institutional Review Board
LTC	Lieutenant Colonel
M16	5.56 mm service rifle
M2	.50-caliber machine gun
M240	7.62 mm machine gun
M9	9 mm Berretta
MPI	Mean Point of Impact
NHQC	Navy Handgun Qualification Course
NPS	Naval Postgraduate School
RSO	Range Safety Officer
SNMT	Standard Navy Marksmanship Training
Transtar II	U.S. Treasury Transitional Target
U.S.	United States
USMC	United States Marine Corps

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I. INTRODUCTION

A. OVERVIEW

The U.S. military currently uses a number of virtual marksmanship simulators to help train its Soldiers and Marines in marksmanship techniques. Like all information systems, these virtual marksmanship simulators rapidly become outdated, and need to be upgraded or replaced. One aspect that can potentially be improved is the "realism" of these simulators, generally in regards to their graphics quality. The issue is that simulator realism is a highly complex subject, with many more factors to account for besides just graphics quality. Of course, the critical issue is not simulator fidelity at all but rather trainee performance or training transfer of skilled marksmanship performance. Thus, this thesis will investigate this issue from both the technology and performance viewpoints.

B. PROBLEM STATEMENT

The U.S. military is seeking to improve or replace a number of aging virtual marksmanship simulators with newer, more realistic systems. However, it is unclear what factors impact the "realism" of these simulators. This limits our ability to improve these simulators, which in turn limits our ability to enhance their training potential. The problem is that the relationship between simulator fidelity and efficacy of the training system is unknown.

C. PURPOSE STATEMENT

The purpose of this research is to determine what factors impact the realism of virtual marksmanship simulators, identify how these factors can be improved, and measure the resulting impact on trained performance This will allow us to enhance the realism of these factors, which will in turn enhance the overall realism of the simulators. This is important because being able to clearly define what makes these simulators more realistic will lead to further research to determine if simulators with enhanced realism are more effective at training than their less realistic counterparts.

D. RESEARCH QUESTIONS AND HYPOTHESES

1. Question One

Are there specific factors which impact the realism of virtual marksmanship simulators?

$H0_1$: No specific factors can be identified which impact the realism of virtual marksmanship simulators.

HA_1: One or more specific factors are identified which impact the realism of virtual marksmanship simulators.

2. Question Two

Does improving or enhancing these factors enhance the overall simulation?

$H0_2$: Improving or enhancing a factor, such as graphics quality, will have no discernible effect on a participant's objective score or their subjective experience with the simulator.

HA_2: Improving or enhancing a factor, such as graphics quality, will have a positive effect on a participant's objective score and/or their subjective experience with the simulator.

E. ORGANIZATION OF THE THESIS

This thesis is organized in the following chapters:

- Chapter I: Introduction. This chapter gives a general outline of the work and defines the problem addressed by this research.
- Chapter II: Background. This chapter discusses existing research on simulator realism, marksmanship, and the use of virtual marksmanship simulators.
- Chapter III: Method. This chapter discusses in detail the design of the experiment and the collection of data for the thesis.
- Chapter IV: Results. This chapter discusses the data collected from the experiments and the analysis of it.

- Chapter V: Conclusions. This chapter describes the conclusions drawn from the results of the experiments, and offers some ideas for potential future research.

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II. BACKGROUND

A. INTRODUCTION

While no specific research has been done to determine what factors determine realism in virtual marksmanship simulators, there have been numerous other studies which look at realism in different contexts, both in regards to simulators and otherwise. There have also been many texts written on the topic of marksmanship training. Lastly there is a growing body of research on the effective use of simulators and virtual environments for training. A discussion of these three areas and their overlapping concern follows in the form of a literary review.

Additional background information will come from Meggitt Training Systems (n.d.), makers of the Indoor Simulated Marksmanship Trainer (ISMT) used by the United States Marine Corps, and from Cubic Defense Systems (n.d.), makers of the Engagement Skills Trainer 2000 (EST 2000) used by the United States Army. A thorough review of these systems will be conducted to learn their capabilities and limitations, and determine what, if any features can be improved to enhance the overall realism of the simulators.

B. MARKSMANSHIP TRAINING

Little is known about how ISMT training transfers to live fire. LTC Yates, United States Marine Corps (USMC), studied the effectiveness of the ISMT to train Marines in marksmanship fundamentals (2004). Using 28 participants at Marine Corps Recruit Depot, San Diego, during the initial rifle qualification using the USMC course of fire, a side-by-side comparison was conducted to measure the performance of Marines trained in ISMT compared to Marines who were trained using dry fire, culminating in a final live-fire qualification. The results showed no significant difference in group shots and scores; in other words, the Marines who trained with ISMT performed as well as those who trained without ISMT. LTC Yates concluded that there was a lack of evidence to

support ISMT being used as the only training mechanism without also providing expert instruction. The importance of this study was that the ISMT training was as effective as dry fire.

The U.S. Army Research Laboratory conducted a training transfer study, *A Comparison of Live and Simulated Fire Soldier Shooting Performance* (Scribner, 2007), using the Dismounted Infantry Survivability and Lethality Testbed simulation-based training to determine the transfer to live training. 12 participants completed a course of fire using the M16 to fire at 18 pop-up target silhouettes. Firing ranges consisted of 75, 100, 150, 200, 250, and 300-meter targets from a kneeling, foxhole-supported position. Each participant was exposed to 10 trials of simulation and live fire, and hit percentage, shot-reaction time, shooting performance, and radial-aiming error were assessed under both conditions. Both simulation and live fire showed similar hit percentages, indicating that participants maintained performance from simulation to live fire. In live fire, each shot took less time and reaction times were faster compared to the shots and reaction times in the simulation. The difference in reaction times may be attributed to many factors including human attributes such as rifle movement with a live weapon or outside weather conditions. The notion that there is a strong relationship between basic marksmanship skills in simulation and live fire is supported by this research.

The Army Research Institute for the Behavioral and Social Sciences' Research Report 1761 (Hagman, 2000) compared simulated marksmanship training to standard Army instruction with a final live fire qualification course of fire. 184 participants trained with simulation, while 202 participants trained with standard Army instruction. All participants completed 11 periods of instruction, ranging from introduction to basic rifle marksmanship and mechanical training to practice firing, leading up to firing for qualification. The dependent variables were the number of targets hit and rounds fired during training and qualification fire. Results indicated that the use of simulation for basic rifle marksmanship training reduced the number of live rounds fired, increased the number of participants firing to standard requirements, and increased the number of target hits. Simulation did not improve record fire qualification scores. The results of the

Research Report 1761 (Hagman, 2000) suggest that simulation-based marksmanship training would improve initial entry rifle marksmanship performance, while saving ammunition.

Getty (2008) compared simulation marksmanship training using the ISMT to SNMT with a one-week gap between training and qualification course of fire. A between-groups study was conducted with random selection of participants blocked by previous marksmanship experience in which half of the participants received training in the ISMT, while the other half received SNMT. The dependent variables were diameter size of average group shots, diameter size of group shots and length of mean point of impact (MPI) to center zeroing point for the three, seven, and 15-yard lines, and overall scores on the NHQC course of fire. Getty's findings show there was no change in participants' marksmanship performance and scores regardless of whether they received the ISMT training or the SNMT, except for the seven-yard line. For the seven-yard line, participants who received the ISMT training showed greater improvements in performance than participants who received SNMT. Exploratory analyses suggest that simulation training may be most beneficial for less experienced shooters. Additionally, there was no significant difference in skill retention after one week between the ISMT participants and SNMT participants, suggesting that a longer period of time is needed to detect group differences in the retention of skills.

In summary, the studies by LTC Yates (2004), ARL-TR-4234 (Scribner, 2007), and Research Report 1761 (Hagman, 2000) show that simulation is at least as effective in marksmanship training as current standard Army and Marine marksmanship training and can be a cost-effective way to train. However, neither of these two key reports identified the roll of fidelity to training effectiveness.

C. SIMULATORS AND VIRTUAL ENVIRONMENTS

Despite how commonly virtual environment trainers are used there are many fielded virtual environment trainers for which there has been no detailed study conducted to validate the effectiveness of a virtual environment trainer. Such studies are referred to as verification of skills acquisition (or training transfer.) A positive verification of skill

acquisition requires a quantified measure of improvement at task performance (Fredriksen & White, 1989). To justify the expense of developing and fielding virtual environment trainers they must be verified to accomplish skill acquisition as well as conventional methods of training, or a reduced level of effectiveness must be accepted as a trade-off for reduced cost or increased safety.

It is a common misunderstanding by some potential consumers of virtual environment trainer technology that a virtual environment trainer is a revolutionary device that must or should accomplish training transfer more rapidly than conventional training methods. Since Edward Thorndike published his seminal work on educational research over 90 years ago, there has been debate about whether a certain type of media used in training or education is qualitatively superior to other methods (Thorndike, 1912). A virtual environment trainer can be viewed as simply a different media of instruction (Clark, 1983). Some studies have shown a difference in relative achievement between groups that received training on the same topic using different media; e.g., written instruction compared to graphical instruction (Reiser & Gagne, 1982).

Other studies have suggested that the learning has little to do with the media used and more to do with the methods of instruction (Clark, 1983). That is to say that a three dimensional training virtual environment might not be a superior tool for training to a less sophisticated analog of the task. While the debate over the relevance of media in training has not been resolved, it is likely that the potential for a relationship between media and learning should be viewed as an interaction between cognitive processes and characteristics of the external world. An effective trainer must replicate the actual task to the extent that it results in the same cognitive, perceptual and motor processes as the actual task. A device that achieves rapid training or skills development is certainly worth pursuing but the potential benefits of most existing virtual environment trainers lie in the ability to conduct training inexpensively, safely, and at the times and places of convenience rather than tying training to a geographic location. A virtual environment trainer may not be a revolutionary device but it can fill a niche that conventional training methods cannot (Schlager, 1994).

This thesis is concerned specifically with validating the effectiveness of the ISMT (Indoor Simulated Marksmanship Trainer) at training novice shooters in the fundamentals of marksmanship. The ISMT is a virtual environment trainer that employs modified infantry weapons, a video projection system, and a precision sensor controlled by two Microsoft Windows based computers. The ISMT was not the first virtual environment trainer developed for marksmanship training. In the early 1980s the U.S. Army developed the Weaponeer marksmanship trainer and employed it to teach initial entry soldiers the fundamentals of marksmanship (Schendel & Heller, 1985). The Army Research Institute developed the Multipurpose Arcade Combat Simulator (MACS) as a trainer for basic marksmanship at about the same time that Weaponeer was developed (White, Carson, & Wilbourn, 1991). Having evaluated these systems the Marine Corps developed a requirements document for a marksmanship trainer for which the ISMT was eventually procured.

D. REALISM

While no specific research has been done to determine what factors determine realism in virtual marksmanship simulators, there have been numerous other studies which look at realism in different contexts. Fencott (1999) believes that as presence is based on perception, it is the content of the virtual environment, and how that content is designed, that is most important. Prothero, Parker, Furness and Wells (1995) agree with this, saying that presence is enhanced by how the user perceives the space, specifically, an increased sense of presence results from a wide field of view and a sense of foreground and background, which enables the user to orient themselves in space and understand the orientation of virtual objects in the same space. McMahan (2003) describes realism as how accurately the virtual environment represents objects, events and people. She goes on to say realism is subdivided into social realism (the extent to which the social interactions in the virtual reality environment matched interactions in the real world), and perceptual realism (how closely do the objects, environments, and events depicted match those that actually exist). In looking at medical simulators, Alessi and Trollip (2001) introduce a model which suggests that as realism increases then the

learning outcomes reach an optimum level but subsequently will drop off for individuals who are novices or of intermediate knowledge in the skills or content domain of the simulation or educational game. Research done by Tashiro and Dunlap (2007) explains that this decrease in learning as realism increases could be due to a confounding of realism and engagement with less motivation to remain engaged as realism swamps the novice and intermediate knowledge users within the simulation or gaming environment. Brooks (1999) describes a number of shortcomings in virtual reality simulators, and offers potential ways to improve them.

III. METHOD

A. OVERVIEW OF RESEARCH DESIGN

The experimental design for this thesis utilized a within-groups study of civilian and active duty military volunteers randomly selected to complete two different scenarios in the ISMT. Marksmanship performance was measured by score using the NHQC firing sequence. This thesis research was approved by the Naval Postgraduate School (NPS) Institutional Review Board (IRB); IRB approval number NPS.2012.0080-IR-EP7-A.

B. PARTICIPANTS

All participants were either students or faculty at NPS. A total of 17 participants, including 15 active duty military and two civilians, took part in this study. Of the 15 active duty military participants, two were from foreign services, and the remaining 13 were from the U.S. military. Of the 17 initial participants, all 17 completed the pre-experiment demographics survey. Table 1 characterizes the participants' general demographics, while Table 2 characterizes their previous marksmanship experience.

Table 1. General Statistics from Participants' Demographic Surveys

Demographics Survey (General)	
Age (%): Years	
28–32	17.65%
33–37	41.18%
38–42	23.53%
43+	17.65%
Corrected Vision (%):	
Yes	41.18%
No	58.82%
Branch of Service (%):	
Navy	52.94%
Marines	17.65%
Army	11.76%
Air Force	5.88%
Civilian	11.76%
Job Specialty (%):	
Combat Element	35.29%
Support Element	64.71%
Video Game Player (%):	
Yes	47.06%
No	52.94%
Video Game Play Time (%): Hours per Week	
0–5	76.47%
6–10	17.65%
11–15	5.88%
16–20	0.00%
21+	0.00%

The general information from the demographic surveys was collected and analyzed in order to determine if there were any other scientifically interesting elements which may impact the participants' scores. These findings are discussed in further detail in Chapter IV.

Table 2. Marksmanship Specific Statistics from Participants' Demographic Survey

Demographics Survey (Marksmanship)	
Qualified With M9 (%):	
Yes	88.24%
No	11.76%
Self-Reported Currency (%):	
Very Current	5.88%
Current	11.76%
Neutral	17.65%
Out of Date	47.06%
Very Out of Date	17.65%
Self-Reported Proficiency (%):	
Very Proficient	11.76%
Proficient	17.65%
Average	47.06%
Beginner	5.88%
Complete Novice	17.65%
Used Virtual Marksmanship Simulators (%):	
Yes	52.94%
No	47.06%

The marksmanship information from the demographic surveys was collected and analyzed in order to determine if participants' prior marksmanship experience had an effect on their scores in the testing. These findings are discussed in further detail in Chapter IV.

C. EQUIPMENT

1. ISMT

ISMT is currently employed by the USMC as a portable, stand-alone marksmanship trainer. ISMT is a "three dimensional simulation based trainer for indoor use, capable of instructing in basic and advanced marksmanship, shoot/no-shoot judgment, combat marksmanship, and weapons employment tactics" (U.S. Marine Corps

Concepts in Programs, 2008, p. 214). ISMT has the capability to use a wide variety of weapons, including the .50cal. machinegun (M2), 9 mm Beretta (M9), 5.56 mm service rifle (M16), 7.62 mm machinegun (M240), and many more. The ISMT located at NPS can train up to two individuals at a time. ISMT has the unique capability to "provide immediate feedback to the instructor and trainee on weapon trigger pull, cant position, barrel movement, rifle butt pressure, tracing of the muzzle on a weapon prior to and after shoot, and grouping" (Getty, 2008). Immediate feedback is vital in marksmanship training because it provides the opportunity for participants to adjust the weapon accordingly, thereby greatly improving accuracy. Just as important, ISMT records muzzle movement and displays the recording as part of the trace profile feature. The trace profile feature records 0.2 seconds before the trigger squeeze, the actual trigger squeeze, and 0.2 seconds post trigger squeeze. The data displayed from the trace profile feature allows the instructor to critique the participant's technique, which would be nearly impossible to do via the naked eye.

The ISMT lab is located in a 30-foot trailer on the NPS campus. The front section of the trailer contains the stored weapons and two Windows-based computers that run the ISMT. The weapons used in this research were tethered to the CO_2 cylinder bank and the ISMT operating system, with input leads consisting of a hose for CO_2 and a wire harness to provide audio and system feedback. The main section of the trailer contains the instructor control panel, just forward of the firing line. This was used to start and stop each scenario, playback scores, and switch between scenarios. Also behind the firing line is the CO_2 cylinder bank that provides the recoil for the weapons. The projector that displays the video for the scenario and the camera that reads the laser from the weapons are mounted on the ceiling in the main section of the trailer. The large projector screen that displays the scenarios and the subwoofers that provide audio for realistic weapon firing sound effects are located at the end of the trailer.

D. MEASURES

1. Demographics

A general demographics survey was administered which contained questions about such topics as age, service, and job specialty (see Table 1).

2. Marksmanship Experience

A survey was administered that asked questions regarding participants' previous marksmanship experience (see Table 2).

E. ISMT SCENARIOS

The ISMT system used for this research was a USMC version which contained a number of USMC-approved scenarios, as well as some user-made Navy-specific scenarios, including the Navy Handgun Qualification Course (NHQC). The two ISMT scenarios (low resolution and high resolution) that were used for this research were designed by this researcher using a modified version of the NHQC.

The NHQC was conducted as follows: a total of thirteen separate Transtar II silhouette targets were displayed one at a time, at three different ranges (see Figure 1). Before each target was displayed the shooter received instructions given by the instructor. Each target appeared for a set duration of time, and had to be shot a set numbers of times to receive maximum score.

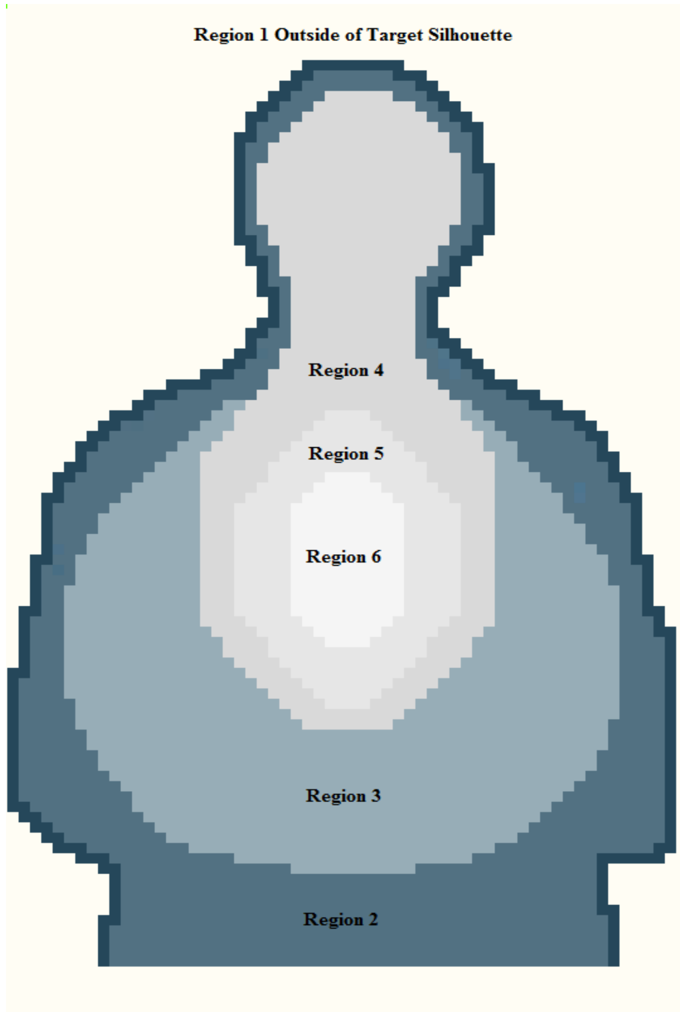

Figure 1. Transtar II Silhouette Target with Regions (From Getty, 2008)

Normally when conducting the NHQC on a live fire range, the shooter will be given six magazines total; four magazines with six rounds in each magazine for the three- and seven-yard line firing sequences, and two magazines with 12 rounds in each magazine for the 15-yard line firing sequence. In order to streamline the experiment, participants were given a single magazine which they simply had to eject and reinsert into the weapon, which allowed the ISMT software to recognize the weapon as being reloaded. The instructions for the NHQC firing sequence were read from OPNAVINST 3591.1F (Chief of Naval Operations, 2009). Refer to Table 3 for a detailed description of NHQC firing sequence, Figure 2 for the participant's view of the simulated range, and Figure 3 for the instructor's control panel display screen.

Table 3. Navy Handgun Qualification Course Firing Sequence

Yard Line	Rounds	Sequence	Remarks
3	12	Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 2 rounds, reload 6 rounds, and fire 2 rounds in 10 seconds	4 rounds strong hand supported position
		Draw and fire 4 rounds in 8 seconds	2 rounds strong hand supported position, 2 rounds weak hand supported position
7	12	Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 2 rounds, reload 6 rounds, and fire 2 rounds in 10 seconds	4 rounds strong hand supported position
		Draw and fire 4 rounds in 8 seconds	2 rounds strong hand supported position, 2 rounds weak hand supported position
15	24	Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 2 rounds in 4 seconds	2 rounds strong hand supported position
		Draw and fire 4 rounds in 8 seconds	4 rounds strong hand supported position
		Draw and fire 4 rounds, reload 12 rounds, and fire 4 rounds in 20 seconds	8 rounds strong hand supported position
		Draw and fire 8 rounds in 20 seconds	8 rounds kneeling position

Figure 2. Participant’s View

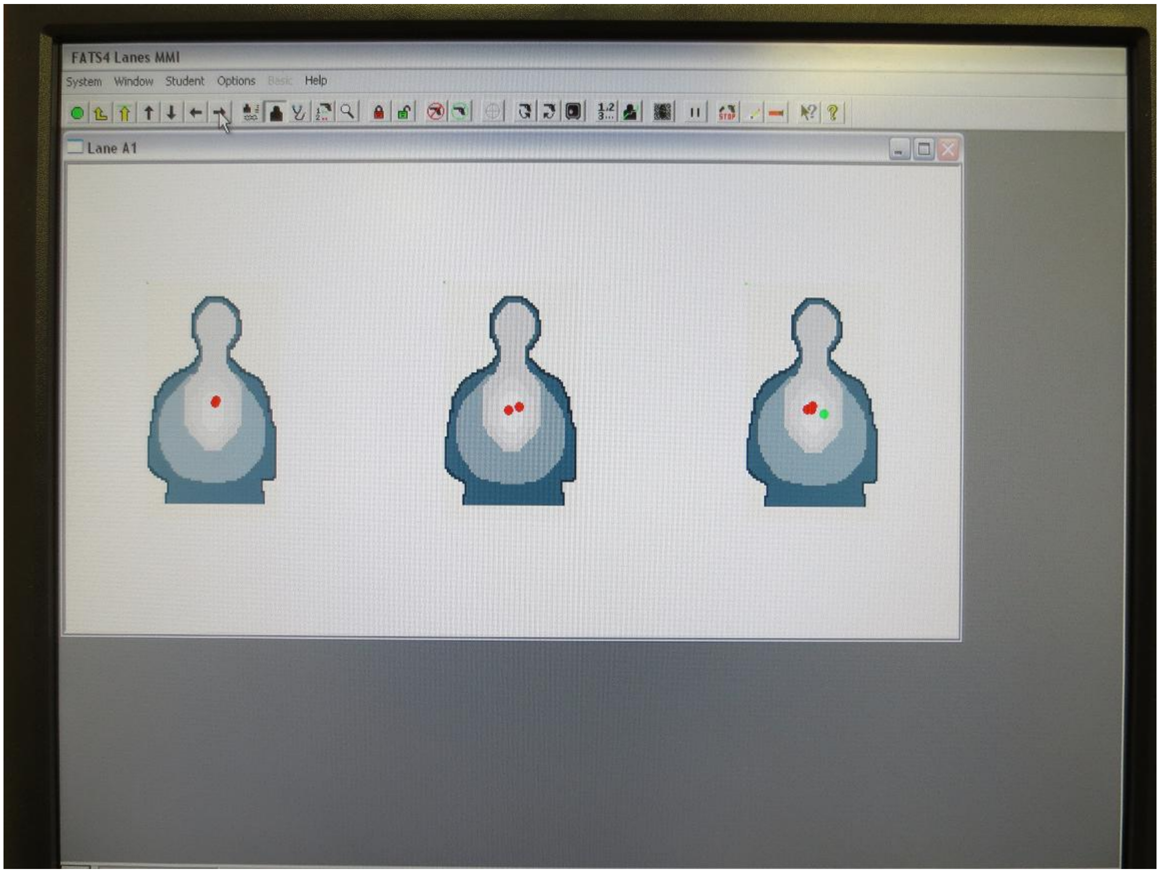

Figure 3. Instructor Control Panel

1. Low Resolution Scenario

The low resolution scenario was a modified version of the NHQC already programmed into the ISMT system. The NHQC featured a background image of a U.S. Navy warship flight deck, an image which would be familiar to anyone in the Navy who has conducted a gun qualification on the flight deck of a ship. This scenario was modified, and the background image was changed to a plain gray screen. The time delay between each target was also reduced in order to minimize the time required by participants. Other than these two changes, the scenario followed the rest of the NHQC. Figures 4 shows the low resolution scenario targets displayed at three, seven, and 15 yards, respectively.

Figure 4. Low Resolution Scenario Targets

2. High Resolution Scenario

The high resolution scenario was a modified version of the NHQC already programmed into the ISMT system. The NHQC featured a background image of a U.S. Navy warship flight deck, an image which would be familiar to anyone in the Navy who has conducted a gun qualification on the flight deck of a ship. This scenario was modified, and the background image was changed to an image of a hallway inside a building. The time delay between each target was also reduced in order to minimize the time required by participants. Other than these two changes, the scenario followed the rest of the NHQC. Figures 5 shows the high resolution scenario targets displayed at three, seven, and 15 yards, respectively.

Figure 5. High Resolution Scenario Targets

F. PROCEDURES

Before participants arrived for a session, the author ensured the ISMT was ready. First, a ready line and a firing line were established in accordance with OPNAVINST 3591.1F (Chief of Naval Operations, 2009) and marked in ISMT by placing masking tape on the deck at the appropriate distances from the projector screen. General safety rules were posted next to the firing line and participants were instructed to read them prior to commencing training. The author ensured the ISMT system was calibrated prior to each participant's arrival. Following system calibration, the M9 was registered and calibrated to the ISMT. The registration process consisted of the instructor firing one round at the screen when prompted by the ISMT. The laser-reading camera would read the individual pulse-coded laser for that particular weapon and register it in the ISMT system.

All participants were either students or faculty at NPS. Recruitment was conducted via e-mail. Participants signed up for individual 30-minute time blocks throughout a two week period. When the participants arrived at the ISMT they were given a consent form to read and sign. After giving consent, participants were asked to fill out a demographics survey. The demographics survey contained questions about the participants' general characteristics, marksmanship skill level, and marksmanship experience.

Once the survey was complete the participants received a small amount of baseline training. Prior to beginning the baseline training, every participant received a safety brief in addition to an overview of the procedures used in this part of the training. The safety brief was conducted in accordance with OPNAVINST 3591.1F (Chief of Naval Operations, 2009) to ensure all safety requirements were met. Baseline training ensured that every participant began with a basic level of knowledge on how to properly handle and fire the M9, which included the proper use of the M9 and specific weapon commands for the experiment (Getty, 2008). Because all participants had different competency levels, baseline training varied between participants. Some required little to no training at all, while others required significant training and practice. In all cases, training and practice was continued until the participant felt comfortable with the weapon

and the ISMT scenario, and indicated they were ready to begin the experiment. Baseline training was conducted using the same gray background as in the low resolution scenario described above. Table 3 provides a detailed description of the baseline training topics.

Table 4. Baseline Training Program (From Getty, 2008)

Baseline Training
General Range Safety Rules
General Safety Rules
Weapon Conditions
Weapon Commands
Pistol Safety Rules
Ready Line
Firing Line
Range Operations
Training Time Out
Loading the Pistol
Making the Pistol Ready
Fire
Cease Fire
Unload, Showing the Pistol Clear
Dry Reload
Isosceles only
Isosceles Standing Position
Isosceles High Kneeling Position

The NHQC firing sequence was used for all data collection shooting events. Each participant shot from the same location marked by blue masking tape on the floor of the ISMT trailer to indicate the center line to help participants center their bodies on the target. Instead of using holsters, all participants were instructed to hold the weapon in the low ready firing position between each target. The low ready position consists of pointing the weapon downward at a 45 degree angle, with the safety engaged, and the trigger finger straight along the frame of the weapon (see Figure 6). All instructions were read from OPNAVINST 3591.1F (Chief of Naval Operations, 2009) to ensure standardization and consistency. All participants used the isosceles standing position for the first

36 rounds fired and the isosceles kneeling position for the last 12 rounds fired to mitigate any confounds associated with various firing positions and maximize consistency (see Figures 7 and 8).

Figure 6. Low Ready Position

Figure 7. Isosceles Standing Position (From Headquarters, United States Marine Corps, 2003)

Figure 8. Isosceles High Kneeling Position (From Headquarters, United States Marine Corps, 2003)

After baseline training and practice was complete, the participants began the actual experiment. They were randomly presented with either the low resolution scenario or the high resolution scenario first. Once the scenario was started, it advanced automatically until all thirteen targets had been displayed and shot at. Instructions were given by the instructor before each target, prompting the shooter on how long the target would be displayed, and how many times they needed to shoot it. The only other input from the instructor during the experiment was corrective remarks, for example the remark "safety" if the shooter failed to disengage the safety on the weapon. No other assistance was provided. The only feedback given during the scenario was from simulated bullet holes appearing in the target on the screen.

At the conclusion of the first scenario the participants were asked to move to the forward part of the trailer and look away from the screen. This allowed the researcher to

display and write down the participants’ score, and then load the second scenario. Participants were not told how well they scored on the first scenario until the end of the experiment. The second scenario was whichever one (high resolution or low resolution) the participant did not have for their first scenario. After loading the second scenario the participants were instructed to return to the firing line. The second scenario was carried out in exactly the same way as the first scenario, with all the same commands.

At the conclusion of the second scenario the participants were asked to fill out a short post-study survey. The survey included questions about which scenario the participants felt was more realistic, which scenario they believed they performed better on, and whether they felt graphics quality affects realism and training. There were also a few short-answer questions where participants could provide additional feedback and ideas for improvement. Once the participants were finished with the survey the author reviewed their answers, and asked questions about some of them to gain a better understanding as to what the participants experienced. Finally, the participants were told their score from the first round, and showed a replay of their second round, ending with their second round score. Figure 9 shows an example of the final score screen.

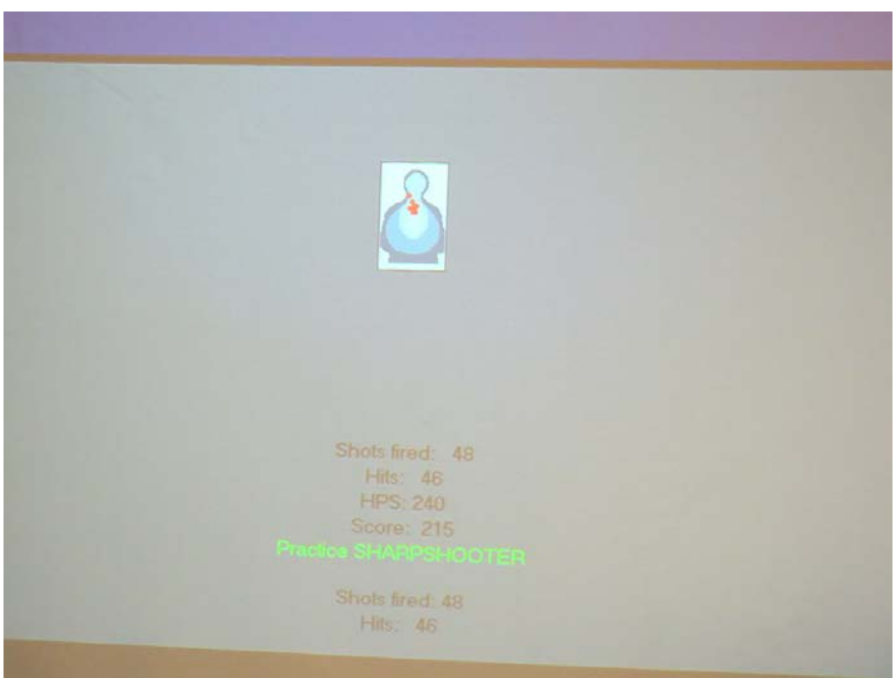

Figure 9. Final Score Screen

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IV. RESULTS

A. DATA PREPARATION AND STATISTICAL METHODS

Demographics survey data was transcribed from paper surveys and recorded in an Excel spreadsheet. It was analyzed using Pearson Product Moment Correlation and two-sample *t*-tests with the data analysis tool package in Excel 2007.

All experimental data sets from ISMT were transcribed from computer-generated data screens into an Excel spreadsheet. Experimental data sets were analyzed using Pearson Product Moment Correlation and two-sample *t*-tests with the data analysis tool package in Excel 2007.

The main variable for hypothesis testing was NHQC score. Scores were graded in accordance with OPNAVINST 3591.1F (Chief of Naval Operations, 2009), based on each shooter's performance, with higher scores indicating better performance.

For the averaged NHQC score, difference scores were calculated on the following data sets: scenario one score to scenario two score, and low resolution-first to high resolution-first score. The difference scores were used to assess changes in performance over time to determine whether any significant improvement or degradation occurred within each group. These difference scores were analyzed using two-sample *t*-tests to determine whether or not the low resolution-first group showed greater levels of improvement than the high resolution-first group.

B. OBJECTIVE ANALYSIS

1. Scores

A total of 17 NPS students and faculty participated in the experiment. Of these, nine received the low resolution scenario first, and eight received the high resolution scenario first. The average score for all 17 low resolution scenarios (213.24 ± 22.38) and all 17 high resolution scenarios (212.65 ± 22.62) showed no significant difference (p =

0.94). Since this finding partially supports $H0_2$, other comparisons were examined to see if graphics quality had any effect on score.

The first thing examined was whether those participants who received the high resolution scenario second had a greater improvement in their scores than those who received the low resolution scenario second. The average scores for scenario one (207.71 ± 23.84) and scenario two (218.18 ± 19.65), clearly show that the participants tended to improve from their first scenario to their second scenario (average improvement = 10.47 ± 10.24 points), regardless of resolution. In fact, all but two participants showed improvement from scenario one to scenario two. This “training effect” was expected, and was the reason why half the participants received the low resolution scenario second, in order to try and counter its effects. Further decomposing these results down between groups, those participants who received the high resolution scenario second had an average improvement of 9.33 ± 12.45 points, while those who received the low resolution scenario second had an average improvement of 11.75 ± 7.67 points. Once again these results showed no significant difference (p=0.63).

Based on the two tests above it appears that graphics quality does not have any effect on average score or score improvement. Therefore, other demographic data was examined to determine if there were other factors which were affecting score.

2. Demographics

The first demographic looked at was age. Participants’ age was correlated against their average score using Excel, returning a value of 0.27. Using a degree of freedom (*df*) of 15, and a two-tailed alpha (*a*) of 0.05, the correlation matrix gives us a significance level of 0.482. Therefore, we can conclude that a participants’ age and their average score are not correlated.

The next demographic looked at was self-reported currency with the M9. Participants’ currency was correlated against their average score using Excel, returning a value of 0.33. Using a degree of freedom (*df*) of 15, and a two-tailed alpha (*a*) of 0.05, the correlation matrix gives us a significance level of 0.482. Therefore, we can conclude that a participants’ currency and their average score are not correlated.

Another demographic looked at was self-reported proficiency with the M9. Participants' proficiency was correlated against their average score using Excel, returning a value of 0.45. Using a degree of freedom (*df*) of 15, and a two-tailed alpha (*a*) of 0.05, the correlation matrix gives us a significance level of 0.482. However, since it is reasonable to assume that there is a relationship between proficiency and average score, using a one-tailed *a* of 0.05 instead is appropriate, which produced a significance level of 0.412. Based on this we can conclude that a participants' proficiency and their average score are correlated.

The author also investigated whether corrective eyewear had an effect on participants' average score. There were seven participants who reported wearing glasses or contact lenses, and 10 participants who did not. The average score of participants with corrective lenses was 200.57 ± 25.00, while the average score of participants with no corrective lenses was 221.60 ± 13.52. A two-tailed *t*-test with an alpha (*a*) of 0.05 revealed a *p*-value of 0.752. A *p*-value below 0.05 is generally considered statistically significant, while one of 0.05 or greater indicates no difference between the groups. Therefore, we can conclude that wearing corrective eyewear had no significant effect on average score. This is further supported by the fact that participants who wore corrective eyewear had an average currency of 1.86 and an average proficiency of 2.43, while those who did not wear corrective eyewear had an average currency of 2.80 and an average proficiency of 3.40. In other words, those participants who did not wear glasses or contacts tended to have a greater currency and proficiency with the M9. Because of this, we cannot say with certainty if their experience or their lack of corrective eyewear affected their score.

The last demographic investigated was whether participants who reported playing video games scored higher than those who did not. There were eight participants who reported playing video games, and nine participants who did not. The average score of participants who played video games was 221.06 ± 14.63, while the average score of participants who did not was 205.72 ± 24.29. A two-tailed *t*-test with an alpha (*a*) of 0.05 revealed a *p*-value of 0.1338. A P-value below 0.05 is generally considered statistically significant, while one of 0.05 or greater indicates no difference between the groups.

Therefore, we can conclude that playing video games had no significant effect on average score. This is further supported by the fact that participants who played video games had an average currency of 2.63 and an average proficiency of 3.13, while those who did not play video games had an average currency of 2.22 and an average proficiency of 2.89. In other words, those participants who played video games tended to have a greater currency and proficiency with the M9. Because of this, we cannot say with certainty if their experience or familiarity with video games affected their score.

C. SUBJECTIVE ANALYSIS

While the primary goal of this research was to collect objective data on participants' scores, a large amount of subjective data was also recorded. This came in the form of participants answers to the post-testing survey questions, as well as informal interviews between the participants and the author following each experimental session. Given the lack of significance in the objective data collected, it is this subjective data that ends up being the most interesting, and perhaps the most useful to the research. Of the 17 participants in this study, all 17 completed the post-testing survey.

1. Graphics Quality and Realism

As part of the post-testing survey, participants were asked to rate the realism and graphics quality of each scenario on a scale of one to five, with one being low and five being high. The average score for realism of the low resolution scenario was 2.12, and for the high resolution scenario it was 3.06. A two-tailed *t*-test with an alpha (a) of 0.05 revealed a *p*-value of 0.011, meaning there was a statistically significant difference between the two scores. Similarly, the average score for graphics quality of the low resolution scenario was 1.71, and for the high resolution scenario it was 2.71. Again, a two-tailed *t*-test with an alpha (a) of 0.05 was conducted and returned a *p*-value of 0.001, meaning there was a statistically significant difference between these two scores as well.

What these two results tell us is that regardless of their performance, almost every single participant felt that the high resolution scenario had better graphics quality and was more realistic than the low resolution scenario. What is not clear from the survey alone is

why participants felt this way. The informal interviews conducted after the testing helped shine some light on this issue. One factor that was pointed out by a number of participants was the contrast between the background and the target. They felt that the target stood out more against the high resolution background, allowing them to more quickly and accurately engage it. Another factor along these same lines was feedback. When the target is shot, simulated bullet holes appear. Because the low resolution background is almost the same color as the center portion of the target, these bullet holes are difficult to see. They become much more visible on the high resolution background. Many participants believed that this improved feedback and made the simulation more realistic. Finally, some participants felt that the high resolution background offered a better frame of reference. On the plain gray background of the low resolution scenario, participants were unsure where the target was going to appear. Conversely, the image of the hallway in the high resolution scenario gave them a frame of reference as to where to expect the target to appear; in this case, in the center of the hallway.

2. Perceived Performance

One question on the post-testing survey asked participants to pick which scenario they believed they performed better on (first or second). Participants answered this question, along with the rest of the post-testing survey, before they were given their scores from either scenario. Of the 17 participants in this study, 10 believed they performed better on the second scenario, while seven believed they performed better on the first scenario. This result was quite shocking, as it was expected most participants would feel they did better on the second scenario, simply due to having more practice from the first scenario. Participants were asked why they felt they did better on a particular scenario, and the answers given were quite interesting. While a large portion of them felt they performed better on the second scenario solely due to practice, a number of other reasons were given as well. At least three participants felt they did better on the first scenario because they knew they missed a shot on the second scenario, and therefore believed that their first scenario score was better. In these cases it did not matter if they had the low resolution or high resolution scenario first.

Another three participants felt that they performed better on the first scenario because it was less distracting. In all three cases they had the low resolution scenario first, followed by the high resolution scenario. Interestingly enough, all three still rated the high resolution scenario as more realistic and having better graphics quality. As one participant explained it, if they wanted to shoot solely for the purpose of getting a high numerical score, they would prefer the low resolution scenario, but if they wanted to receive meaningful, realistic training, they would rather shoot the high resolution scenario.

One participant felt they performed better on the first scenario (high resolution in this case) because it offered a better spatial frame of reference, as discussed above. There was also one participant who felt they did better on the second scenario (high resolution) because of the improved feedback. Finally, there was one participant who felt they did better on the second scenario (high resolution) because it didn't have the "glairing white background" of the first scenario.

In summary, while many participants felt they improved with practice, regardless of background type, there were some who preferred the low resolution scenario because it was less distracting, and some who preferred the high resolution scenario because it was less glairing and offered a spatial frame of reference and better visual feedback. Interesting enough, no participant explicitly cited graphics quality or realism as reasons why they felt they performed better.

3. How Graphics Quality Affects Realism and Training

As part of the post-testing survey, participants were asked if they agreed with three statements on a scale of one to five, with one being "strongly disagree" and five being "strongly agree." The three statements were: "Graphic quality affects realism," "Improving the graphics quality would improve the realism of the simulation," and "Improving the graphics quality would improve the training received." The average responses for these three statements were 4.35, 4.41, and 4.29, respectively. The lowest response given to a question was a three (or neutral), and only three of these were given total. All the remaining answers were either a 4 (agree) or a 5 (strongly agree).

These results are likely the most important of the entire study. They show that a diverse group of military personnel, with different backgrounds and experience levels, all unanimously believe that improving the graphics quality of the simulator would improve the training received. This should serve as strong incentive for the Department of the Navy, and the Department of Defense as a whole, to study this issue further before procurements of new simulators is made.

4. Open Answers and Additional Feedback

The final part of the post-testing survey asked the participants to provide additional feedback via three open-answer type questions. These questions were:

“What other factors besides graphics quality do you believe affects realism?”

“What factors would you change to improve the training simulation?”

“Do you have any other ideas for improvement?”

A wide array of answers were given, including sound effects, voice, target movement, general ambience of the training environment, interactive scenarios, wearing combat gear, smoke, requiring the shooter to move, lighting, and quality of the weapon analogue.

A number of participants believed that additional sounds, background noise, and distractions in general would improve the realism of the simulator. Things like people talking, vehicle noises, and even other weapons being fired were cited as examples.

Many participants believed that having better, more realistic scenarios would greatly improve the overall realism of the simulator. Some commonly cited examples were: have targets that look like real human beings, have targets that move, have targets that speak, make gestures, and points weapons (a way to show hostile intent), require the shooter to interact, make decisions, and even issue voice commands.

Environment and ambiance were considered important factors as well. Some participants found the lighting in the trailer (dark trailer with bright screen) to be highly unrealistic, and believed that a more natural daylight or nighttime system would be better.

Other environmental factors such as wind, rain, hot and cold temperatures, and even smells were cited as possible ideas for improvement.

Finally, a number of the participants commented on the quality of the weapon analogue. While most participants found it highly realistic, a number of problems were pointed out. First, the air house/data cable tether that connects the weapon to the rest of the ISMT makes movement more restricted, and causes a break in the users' immersion in the simulator. It also makes the weapon harder to reload, which could adversely affect training. Second, while the air system allows the weapon to recoil, it has nowhere near the same force as a real live-fire weapon. Similarly, the sound of the weapon firing comes from the simulator speakers, and is a fraction of the loudness of a true firearm. Finally, no muzzle flash is produced when the weapon analogue is fired. All these factors hamper the realism of an otherwise outstanding weapon analogue.

V. CONCLUSION AND RECOMMENDATIONS

A. SUMMARY

The purpose of this research was to determine what factors impact the realism of virtual marksmanship simulators, identify how these factors can be improved, and measure the resulting impact on trained performance In the future this will allow us to enhance the realism of these factors, which will in turn enhance the overall realism of the simulators. This is important because being able to clearly define what makes these simulators more realistic will lead to further research to determine if simulators with enhanced realism are more effective at training than their less realistic counterparts.

This study focused primarily on the factor of graphics quality of the ISMT. The goal was to see if improving the graphics quality of an ISMT scenario (by changing the background image) would have any impact on the performance of the shooters, or affect their subjective experience of the simulator.

B. HYPOTHESIS ONE DISCUSSION

Are there specific factors which impact the realism of virtual marksmanship simulators?

$H0_1$: No specific factors can be identified which impact the realism of virtual marksmanship simulators.

HA_1: One or more specific factors are identified which impact the realism of virtual marksmanship simulators.

While no conclusive objective data identified any factors which impact the realism of virtual marksmanship simulators, there was subjective data to suggest that graphics quality, as well as a number of other factors, impact the realism of virtual marksmanship simulators.

Based on their answers to the post-testing survey, participants overwhelmingly agreed that graphics quality affects realism, with only a single participant being neutral.

Participants also provided a wealth of other possible factors which may affect realism. These included sound effects, voice, target movement, general ambience of the training environment, interactive scenarios, wearing combat gear, smoke, requiring the shooter to move, lighting, and quality of the weapon analogue.

C. HYPOTHESIS TWO DISCUSSION

Does improving or enhancing these factors enhance the overall simulation?

$H0_2$: Improving or enhancing a factor, such as graphics quality, will have no discernible effect on a participants objective score or their subjective experience with the simulator.

HA_2: Improving or enhancing a factor, such as graphics quality, will have a positive effect on a participants objective score and/or their subjective experience with the simulator.

While the objective data taken from shooters scores showed no improvement between low resolution and high resolution scenarios, the subjective experience of the participants showed positive results. There was a significant difference between both the graphics quality and realism scores reported on the participants' post-testing surveys. Similarly, participants overwhelmingly agreed that graphics quality affects realism, with only a single participant being neutral. Finally, during the informal interviews the majority of participants stated that they preferred the high resolution scenario, and felt it provided better and more realistic training.

D. FUTURE WORK AND RECOMMENDATIONS

The limited size and scope of this experiment limited the quality of the results obtained. Nevertheless, it provided some useful insight into possible future studies, and possible ways to improve virtual marksmanship simulators.

The first thing to try would be varying aspects other than just the background image. Using more complex images, different targets, moving objects, and other changes could easily be made to the existing ISMT program and tested in the same manner.

Likewise, a background image could be made with true high resolution and low resolution versions, for example 640x480 pixels vs. 1600x1200 pixels. Comparing these would show if actual screen resolution has any impact on performance.

Another avenue for future study would be to investigate the other training modes present in ISMT. Currently, ISMT has three training modes: Lanes Training, CGI Collective Training, and Video Training. A brief description of these three modes follows.

1. Lanes Training

Lanes Training is the most basic training mode offered in ISMT. It allows the user to replicate the look and feel of a standard target range. Different background images can be applied to mimic everything from being indoors in a building, to being outside in the woods, to being on the flight deck of a ship. However, in all cases the backgrounds are two-dimensional images and only one can be applied per scenario. The point of view is also fixed, so the user cannot "look around." A variety of targets can be added to the scenario, ranging from simple silhouettes to images of real people. While the targets can be made to move and "pop up," they are still all two-dimensional images, which limits the complexity and realism of the scenarios possible. This experiment used Lanes Training as the sole mode for data collection.

2. Video Training

Video Training is a slightly more advanced mode of training than Lanes Training, with a number of additional features. Video Training uses full motion video (FMV) in place of a background image. In this mode, a video will play, recorded in the real world by real actors. As the video plays the actors will move about, talk, and interact with each other. At some point during the video an actor who is an enemy target may appear, at which point the shooters will have to engage the target. This mode offers a number of benefits over Lanes Training, the first of which is the obvious increase in realism afforded by having a live-action video playing, with real, interactive targets. This mode

can also be used to train decision making skills, as the shooters have to make on-the-spot judgment calls as to whether a target is displaying hostile intent or not, and whether or not they should engage.

Despite these benefits, Video Training still has a number of limitations. First, it is not nearly as easy to modify as Lanes Training. In Lanes Training, creating custom user scenarios is quite simple and straight forward, as only the background and targets need to be manipulated. Creating a custom Video Training scenario would require filming one or more new videos, editing them, importing them into the ISMT system, and then overlaying them with all the appropriate target parameters. The reality is most users will never do this, therefore the same set of premade Video Training scenarios will be used over and over again, until the shooters start to memorize where the targets appear, at which point the training becomes less effective.

As with all the ISMT technology, Video Training is quite old. The quality of the videos is relatively low, and it can often be difficult to make out friend or foe. The inherent limitations of using FMV as a background source also adversely affect realism. This is because multiple videos have to be filmed for each scenario to account for multiple branching paths. However, because there are infinite possible paths, and only a finite number of videos can be filmed, the scenario is often left with gaps. Imagine the following scenario:

> You are presented a video where you are standing guard duty at the gate to a base. A person enters the video from the left side of the screen and begins to walk towards you. Suddenly they pull out a weapon and begin firing at you as they run towards the right side of the screen.

In this case, the producers of the video have only recorded two possible branches. If you fail to engage the target, or miss the target, he successfully runs away. If you accurately engage the target, the person collapses at the right edge of the screen. But what if you shot the target as soon as he pulled out his weapon? Since he continues to move and fire at you, you might logically conclude that you missed and keep shooting him. Only once he finally collapses at the edge of the screen would you receive the necessary feedback to know that you successfully engaged the target.

This mode could be investigated in a number of ways to further the research. A comparison could be done between simple moving targets in Lanes Training, and live-action moving actors in Video Training. In addition, as with the Lanes Training, true high resolution and low resolution versions of the same video could be compared against each other to see if there is any difference in performance.

3. CGI Collective Training

The final mode built in to the ISMT is the CGI (Computer-generated imagery) Collective Training mode. It is by far the most advanced mode available, and it closely resembles a commercial video game. CGI Collective Training is also the only three-dimensional mode available. In this mode, full 3D environments can be built through the use of an editor. Then 3D models of everything from people to vehicles to aircraft can be inserted into this environment. The shooter is shown the field of view of his avatar. The avatar can be moved throughout the environment, and change its field of view using a joystick connected to the instructor terminal. The avatar can also be mounted in a vehicle, and the vehicle can be programmed to follow a certain course through the environment, simulating a convoy operation.

The benefits of this mode over the previous two are quite obvious. Having a 3D environment allows for much greater immersion on the part of the shooter, and it also allows for much more complex scenarios to be carried out. Using computer-generated 3D models as targets also eliminates the problems encountered with the Video Training mentioned above. Imagine the same scenario; now when the target is shot it will collapse immediately, wherever it is, providing the correct feedback to the shooter, which should result in better training.

As with all the ISMT technology, CGI Collective Training is quite old. The quality of the 3D models and environments is relatively low, and it can often be difficult to make out friend or foe. Most modern video games have exponentially better video quality, and as such young trainees who are familiar with video games may find the graphics of the CGI Collective Training to be unremarkable.

The author believes that this mode holds the most potential for future research. The panicle of this research would be to find some way to use a modern video game graphics engine, such as the ones found in popular games like *Call of Duty*, *Crysis*, or *Halo*, in the ISMT. This could then be compared against the standard CGI Collective Training scenario, to see if shooter performance improves.

E. CONCLUSION

The results of this research indicate that: (1) changing the background image in the Lanes Training mode of the ISMT has no affect on shooter performance, (2) the vast majority of participants believe that increasing the graphics quality of ISMT would increase the realism of the simulation, and increase the training received, and (3) the majority of participants believed that there were many other factors which could be introduced or increased in order to make the simulation more realistic, and improve the overall training experience. This study has only touched the surface of what is possible. There are a number of excellent future research opportunities available, from testing different modes of ISMT, to varying some other factors that might affect realism of the simulation. Given the state of the economy, growing DoD budget cuts, and an increasing shift to a high-tech world, simulation training is becoming more important than ever before. Finding effective ways to improve these simulations so they provide the best, most realistic training possible will be critical in making sure our armed forces are prepared for future conflicts.

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APPENDEX A. INFORMED CONSENT FORM

Naval Postgraduate School
Consent to Participate in Research

Introduction. You are invited to participate in a research study entitled Increasing Realism in Virtual Marksmanship Simulators. The purpose of the research is to determine what factors impact the realism of virtual marksmanship simulators, identify how these factors can be improved, and measure the resulting impact on trained performance.

Procedures. Subjects will be asked to provide consent and answer an initial questionnaire. These will be done when the subject first enters the simulator, and should take approximately 15 minutes to complete. Next the subject will be given a safety brief, and then trained in the use of the simulator, including how to load, fire, and operate the simulator weapons. This process will conclude with the subject calibrating the weapon to their own unique shooting profile. The duration for the safety brief, training, and calibration is approximately 15–20 minutes. As the experiment begins, the subject will be presented with two to four different scenarios, some at a "high resolution" setting, and some at a "low resolution" setting. Subjects will be required to fire at various targets throughout these scenarios. Their scores will be recorded. Time to complete the scenarios is approximately 10–15 minutes. Finally the subjects will be presented with a follow-up survey, where they will be asked various questions about the scenarios and their performance. The survey should take approximately 10 minutes.

Location. The interview/survey/experiment will take place in the ISMT Simulator, located behind Watkins Hall, on the NPS campus.

Cost. There is no cost to participate in this research study.

Voluntary Nature of the Study. Your participation in this study is strictly voluntary. If you choose to participate you can change your mind at any time and withdraw from the study. You will not be penalized in any way or lose any benefits to which you would otherwise be entitled if you choose not to participate in this study or to withdraw. The alternative to participating in the research is to not participate in the research.

Potential Risks and Discomforts. The potential risks of participating in this study are: Simulator sickness, eye strain, and arm strain from holding the weapon. You will be notified about all the risks before beginning the experiment, and reminded that you can and should stop as soon as you feel any discomfort. The researchers will constantly monitor for any signs of discomfort, and terminate the experiment if they believe you are experiencing any discomfort. You will be given time to rest between scenarios in order to minimize eye strain and arm fatigue.

Anticipated Benefits. Anticipated benefits from this study are the potential to help define what factors affect realism in virtual marksmanship simulators, and determine if improving these factors improves the overall simulation. This knowledge can be used to help create new, more realistic, more effective simulators in the future. You will not directly benefit from your participation in this research.

Compensation for Participation. No tangible compensation will be given.

Confidentiality & Privacy Act. Any information that is obtained during this study will be kept confidential to the full extent permitted by law. All efforts, within reason, will be made to keep your personal information in your research record confidential but total confidentiality cannot be guaranteed. All hard-copy records will be kept in a folder, which will always be in the possession of the researcher, or locked in a secure location. All electronic data will be stored in a secure folder on the researchers laptop.

Points of Contact. If you have any questions or comments about the research, or you experience an injury or have questions about any discomforts that you experience while taking part in this study please contact the Principal Investigator, Dr. Rudy Darken, 831–656–7588, darken@nps.edu. Questions about your rights as a research subject or any other concerns may be addressed to the Navy Postgraduate School IRB Chair, CAPT John Schmidt, USN, 831–656–3864, jkschmid@nps.edu.

Statement of Consent. I have read the information provided above. I have been given the opportunity to ask questions and all the questions have been answered to my satisfaction. I have been provided a copy of this form for my records and I agree to participate in this study. I understand that by agreeing to participate in this research and signing this form, I do not waive any of my legal rights.

______________________________________ __________________

Participant’s Signature Date

______________________________________ __________________

Researcher’s Signature Date

APPENDEX B: BEFORE TESTING SURVEY

BEFORE TESTING:

1. Service:________________________

2. MOS / Designator:_______________

3. Age:_______

4. Do you wear glasses or contacts? YES / NO

5. Have you ever qualified with the M9? YES / NO

6. How would you rate your currency with the M9?

very out of date	out of date	neutral	current	very current

7. How would you rate your proficiency with the M9?

complete novice	beginner	average	proficient	very proficient

8. Have you ever used a Virtual Marksmanship Simulator? YES / NO

9. Do you play video games? YES / NO

10. About how many hours per week do you play video games?

0-5	6-10	11-15	16-20	21+

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APPENDEX C: AFTER TESTING SURVEY

AFTER TESTING:

1. How would you rate the realism of the first scenario?

very unrealistic	unrealistic	neutral	realistic	very realistic

2. How would you rate the graphic quality of the first scenario?

very low	low	neutral	high	very high

3. How would you rate the realism of the second scenario?

very unrealistic	unrealistic	neutral	realistic	very realistic

4. How would you rate the graphic quality of the second scenario?

very low	low	neutral	high	very high

5. On which scenario would you say you performed the best? ______

For the following three questions, please choose whether you agree or disagree with the statement.

6. Graphics quality affects realism.

strongly disagree	disagree	neutral	agree	strongly agree

7. Improving the graphics quality would improve the realism of the simulation.

strongly disagree	disagree	neutral	agree	strongly agree

8. Improving the graphics quality would improve the training received.

strongly disagree	disagree	neutral	agree	strongly agree

9. What other factors besides graphics quality do you believe affect realism?

10. What factors would you change to improve the training simulation?

11. Do you have any other ideas for improvements?

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